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Rochelle Salt (Potassium Sodium Tartrate Tetrehydrate) Growth Process- 1.1RSGP

This report is an observation on a single artificial growth trial of Potassium Sodium Tartrate Tetrahydrate (Rochelle Salt). Rochelle Salt is a crystal material with ferroelectric, pyroelectric and in particular piezoelectric characteristics.

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Documentation Section

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Abstract

This report is an observation on artificial growth of Potassium Sodium Tartrate Tetrahydrate (Rochelle Salt) and explained is the method and result. Rochelle Salt is a crystal material with ferroelectric, pyroelectric and in particular piezoelectric characteristics. The experiment is of a first time attempt, from the mixture and heating of ingredients, the filtering and cooling to form the crystals, then lastly a second heating and cooling process. This experimental trial is to freely share information of the growing process of Rochelle Salt including common mistakes made. Intention in future is to use the knowledge to proceed with hypotheses regarding growing modified forms of piezoelectric materials, however discussion of these are only mentioned since they are out of scope of this report. In focus is a basic observation of the experiment and not a recipe, however information on the steps and actions taken to create Rochelle Salt will be discussed throughout the method section. The experiment was ultimately a failure from both oversaturation in the first growing process and also what is suspected as overheating in the second filtering process. The observations as to why these two things occurred are detailed in the results and discussions sections and are addressed as changes to be made in future experimental trials. To give better relevance and understanding to the experimental trial, a brief explanation of piezoelectric material's characteristics, capabilities, and how they work has been included in the introduction section.

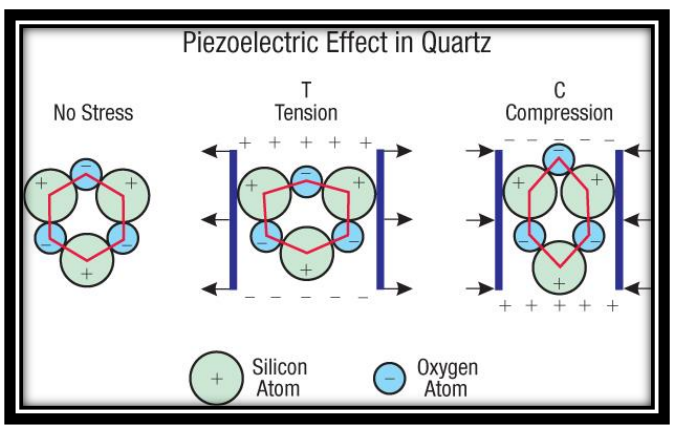
Introduction

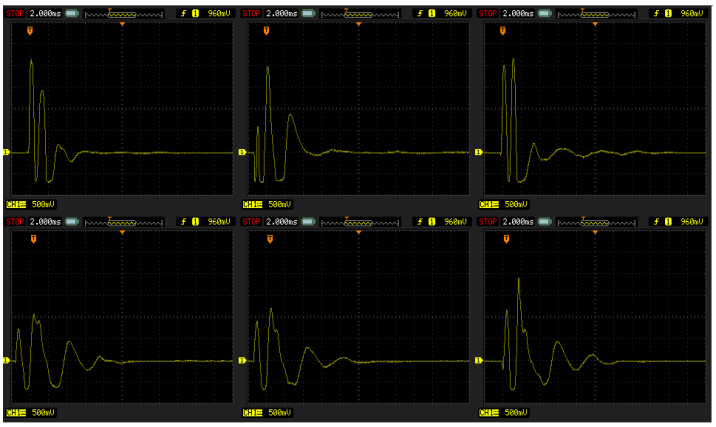
Rochelle Salt is a type of piezoelectric crystal, *Piezo* meaning “pressure” in Greek which is an effect that when certain materials are compressed, they exhibit an electrical charge often in very low voltages. The effect was first demonstrated in 1880 by French Physicists brothers Pierre Curie and Jacques Curie who experimented on a number of crystals including Topaz, Tourmaline, Cane Sugar, Quartz and Rochelle Salt. They found that the effect was best exhibited by Quartz and Rochelle Salt. Biological materials such as bone and tendons also exhibit piezoelectric properties from collagen. A characteristic of piezoelectric materials is that the effect is able to be reversed, called the inverted piezoelectric effect. If an electrical signal is applied to the material it causes the structure to physically deform in tune to the electrical signals frequency and amplitude, making noise through vibration. Piezoelectric materials can be found used in quartz wrist watches to keep the frequency of its timing, Buzzers and alarms through the inverted piezoelectric effect and musical instruments and microphones to pick up soundwaves to be converted into an electrical signal and out through an amplifier.

An explanation of the piezoelectric effect can be described through a quartz crystal. The molecular lattice is made up of both Silicon atoms (positively charged) and Oxygen atoms (negatively charged) formed in a geometrically symmetrical arrangement, resting in a neutral state. As per the bottom left photo when the crystal is compressed inwards, molecularly its structural lattice is deformed upwards and downwards due to the inward pressure. A greater area of positively charged Silicon atoms are forced to move downwards and greater area of negatively charged Oxygen atoms are forced upwards causing a potential charge difference. When this compression happens the response molecularly is the structure deforming itself in the other direction producing an alternating current, this is observed when the electrical output signal is tested with an oscilloscope.

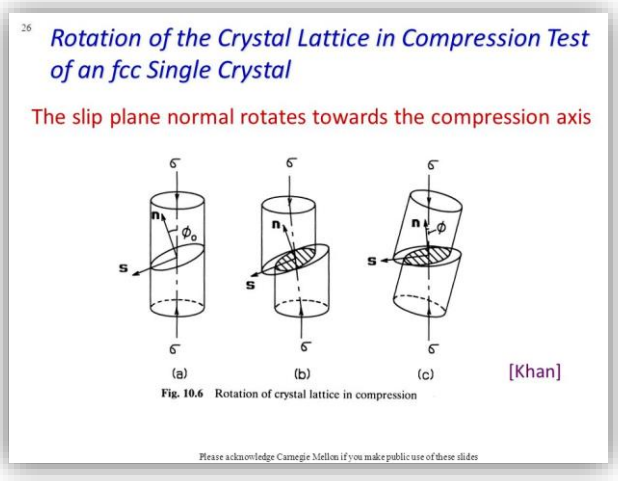
The photo below left shows how the deformation of Quartz lattice from mechanical stress forces positively and negatively charged atoms to move position and create that potential difference.

The photo below right is the electrical signal of a non-specified piezo transducer being tapped. It shows an AC sine wave and demonstrates the moving between crests and troughs as it cycles through a small number of wave phases before resting back to its neutral state. Showing the potential difference of the lattice deforming.





Piezoelectric materials are incredibly fascinating and exhibit characteristics and responses to certain actions that are not widely known. Piezoluminescence is a phenomenon when high stress tolerant piezo crystals such as Quartz are subjected to high levels of pressure they produce light. A light flickers and flashes from within the body of the crystal and has found to be best produced by high stress drilling action. Piezoelectric materials also have what a called slip planes. Slip planes are openings between the aligned arrangements throughout the molecule structure. These slip planes are areas that are susceptible to shearing and damage to the structure when subjected to inverted piezoelectric charge. If the charge induced is at the materials resonate frequency, it causes an overcharge to the structure resulting in the material physically popping and exploding, becoming dangerous relevant to the size of the material. Interestingly, damage is isolated to the areas of which the piezo material has sheared on itself, leaving the still intact areas usable and effective.



This experimental trial to grow Rochelle Salt is a first attempt by myself to create crystals. A successful outcome of the experiment would result in using the seed crystals to then grow a larger Rochelle Salt crystal. In future, it's desired to trial growing crystals to form in certain wafer or grid patterns for small electronic use.

Seed crystals are usually smaller, but are chosen out as well developed, geometrically, and symmetrically shaped. Once a seed crystal is chosen it is suspended into a highly dense solution of its chemical make up to then absorb that solution, resulting in a larger formed crystal upon cooling. The theory of this process is that the molecules in the solution are able to more easily attach themselves to an already formed structure of its own molecular make up. With the hope the molecules attach and develop in the same form as the seed crystal, given the reason to choosing a well developed seed crystal. Generally Seed crystal growth is used as a means to speed up the natural cycle of a certain type of crystal for commercial or industrial use saving time, resources, money, and having more measurable and controllable results.

Method

The method is broken down into 2 stages and 6 steps. The steps are numbered following through both stages continually to keep the process of the experiment bodied as 1. The first main process was to produce the crystals from heating Cream of Tartare and Washing Soda together, filtering the mixture and then cooling that filtered mixture in a container until the crystals were formed. The second process is to dissolve and dilute the formed crystals in distilled water and to cool again to rid impurities such as yellow discolouration. As to not be repetitive in mentioning in each step, a constant slow stirring motion was kept throughout both stages. Note the distilled water as 1L and Sodium Carbonate 500g in the ingredients section. This isn't the total used amount in the experiment, it's the quantity that was purchased as to have more than sufficient amount needing to be used. The correct amount are more accurately detailed within the steps respectively below.

Ingredients: Distilled water 1L, Potassium Bitartrate (Cream of Tartare) 200g, Sodium Carbonate (Washing Soda) 500g

Materials: Thermometer, 500ml Glass measuring jug, Cooking Pot, Stainless Steel stirring spoon, ½ tsp measuring spoon, Coffee Filters, Glass Jar, plastic container.

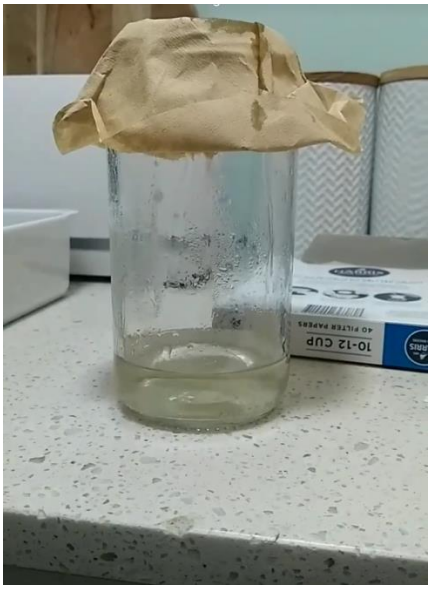
Stage 1 (Initial Crystals Stage):

Step 1: Preparation of Creating Rochelle Salt was to first fill the glass jug up with 250ml of distilled water. The jug was then placed inside the pot and tap water filled around the jug to around ¾ the height of the pot. Placing the jug inside the pot to indirectly heat up the ingredients in the jug and to control the temperature. The reason for filling the pot ¾ high was to compensate for evaporation that may occur. Using the thermometer put into the jug, the distilled water in the jug was heated to 80°c.

Step 2: Once the distilled water reached 80°c, two 125g packets of Cream of Tartare were tipped into the distilled water. The reaction that happened from this was a white bubbly and fermentation looking type of response, as this occurred the temperature of the mixture also dropped almost immediately from 80°c to around 70°c, this was an expected reaction. The initial bubbly, fermenting reaction soon subsided between 10-20 seconds of adding Cream of Tartare and became more of a milky white colouration. The intention was to bring the temperature back up to 80°. The mixture when stirring while bringing the temperature up again was observed as thick and gluggy while retaining its white/milky/creamy colouration and texture. The thick "gluggyness" of the mixture could be felt whilst stirring the mixture with the spoon on the bottom of the jug where the Cream of Tartare settles.

Step 3: Once the temperature was back up to 80°c, no more than a ½ tsp of Washing Soda was added into the mixture. This caused the mixture to bubble, fizz and rise quickly to almost the bream of the jug. Once the reaction subsided down and to a low audible fizzing sound another ½ tsp of Washing Soda was added. The reaction timing from adding Washing Soda and the mixture bubbling/ fizzing and rising was getting more drawn out and delayed as this step was repeated over. Also noting what appeared to be dark brown and black spots appeared on the surface of the bubbles of the mixture throughout. The mixture after around 30-40mins went abruptly from its white bubbly fizzy nature to a clear watery appearance with a low yellowish tone, indicating that enough Washing Soda had been added. The mixture was kept on the heat for another 30 seconds of stirring then taken out of the cooking pot and stove top turned off.

Step 4: While the mixture in the jug was still hot, a coffee filter was placed on the top of the glass jar and formed a cone shape into it. As the mixture was poured into the jar it immediately was pooled up and to better describe, clogged in the coffee filter. The mixture that was being able to filter through was crystallising small deposits on the bottom of the jar after 5-10mins. Once as much of the liquid was filtered the jar was emptied into a plastic container which was then placed in the fridge overnight.



Stage 2 (Diluting Grown Crystals):

Step 5: The remaining liquid in the container was filtered out into a glass jar using another coffee filter, this time being used to catch crystals and to keep them in the container. In the container remained the leftover crystals which had a clear white colouration. More distilled water to cover the bottom of the container was added and swished around to wash out any further sediment discolouration and filtered into the same glass jar. Again the coffee filter used only to separate the liquid from the crystals with the liquid in the jar now being wastage. It filtered only slightly faster through the coffee filter in this step.

Step 6: All the crystals were then scooped up and placed into a clean measuring jug and filled with distilled water 250ml on the jug. The cooking pot was reused the same way with the jug placed inside of the pot. The thermometer was placed inside the jug and heat monitored to no higher than 30°c constantly stirring leaving the mixture suspended the whole time. It was important to keep monitoring the temperature so that it didn't burn out the crystals. This mixture in this process was much clearer and didn't seem to have impurities or any colouration. No bubbling or fizzing was present other than a minor transitional stage of the crystals dissolving into the distilled water. Once the crystals seemed to have dissolved into the water, with only a few sediment crystals left, the heat was switched off and the jug removed from the pot. Noted was the thermometer reading kept climbing whilst the jug was off the heat. Using a clean glass jar and coffee filter the mixture was poured through into the jar one last time. The mixture inside the jar was then poured into a plastic container and left in the fridge overnight to cool.

Results

Stage 1:

The initial result from stage 1 detailed in step 4 described the difficulty of filtering the mixture through the coffee filter due to oversaturation of ingredients. Checking the grown crystals the next morning, the container had randomly distributed clear clusters some larger than others at the bottom of the plastic container. Multiple crystal clusters either stacked, merged into each other or formed out from others with clear yellow toned liquid remaining at the bottom of the container. From information being followed by both online written and video sources the result should have been more evenly distributed smaller fragments of salt deposits separated between each other to form potential seed crystals. The difference of results from the online sources are suspected to be of a number of factors.

One is that the quantity of Cream of Tartare and Washing Soda was too high. Internet sources suggested 200g of Cream of Tartare, however the instructions being followed for stage 1 of the experiment were from video source which used two 125g packets of Cream of Tartare. This would have been the cause for the somewhat overly thick, gluggy texture of the mixture in step 2. Not letting the reaction lower enough before adding more Washing Soda into the mixture in step 3 is also a suspicion to why oversaturation occurred. Because the reactions from the mixture started taking longer to rise and subside, it may have been mistaken as ready to pour in more Washing Soda increasing its quantity more than needed. However, this is only speculation as this stage wasn't measured accurately enough during the process.

Stage 2:

The final results seen the next morning after step 6 were found to have no crystals formed and only clear watery liquid remained in the container. Overheating in stage 6 is suspected to be the cause of the results. What's expected is that the crystals will dissolve into the distilled water without breaking down material structure, resulting in a less saturated Potassium Bitartrate solution and a more Potassium Tartrate solution. What is suspected is that the thermometer being used wasn't keeping the temperature readings updated fast enough, giving a false lower impression of how hot the mixture was. Evidence for this is noted when the jug was taken out from the pot, the temperature still kept rising on the thermometer by 4°c until it started lowering again. Having observed that no crystals at all were formed, it may also have been a factor of diluting the crystals in too much distilled water.

Discussion

The results from both stages 1 and 2 found that there were a number of factors throughout the experiment that need to be more closely monitored and measured. The most apparent being a more strict measurement of the ingredients particularly the Sodium Carbonate as this wasn't measured at all. The reason for this was online sources that they too hadn't measured this step of the process. Measuring the Sodium Carbonate content will result in a quicker diagnostic of saturation levels because the input of the ingredient can be varied depending on reaction times of the mixture in step 3. The same principle of quicker diagnostics can be said with more closely monitored measurements of ingredients, also making following attempts to grow crystals easier to isolate adjustments for specific outcomes. The Temperature for step 6 is needed to be more closely monitored as this is a sensitive step in trying not to burn the crystal solution.. Because the jug is sitting in the pot on the stove top, even if turned off the temperature will still rise. Taking the jug out of the pot entirely if it's on 29°c will still have the contents increase in temperature but avoid undesired levels.

The cooling container being used was also suspected as effecting the outcome of results. From the written and video sources used online to conduct the trial, they used large, wide trays to cool their crystals in. Some of these were plastic however some were glass. Glass or china trays should be considered as a better options for cooling because these will have less chemical interference with the growing process. From the photos above it is seen that the container used in this experiment is a soft plastic, smaller bottom surface area and deeper. This creating a pooling effect to the crystal solution, in turn encouraging the crystals to grow thicker with little room to spread out for thinner, better formed seed crystals. Detailed in the introduction section is the desire to use seed crystals for larger growths. However from this particular experimental trial, more attempts will be necessary and improving the results above will need to be taken into account to achieve this.

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